

with a little care it was not difficult to adjust the level of the paper, so that very little displacement was called for to meet the requirements of the pen's descent towards the centre of the figure, and that little was granted at once by the facility with which the india-rubber yielded to the demand. When the suspension was ill-adjusted, so that the pen-point pressed too heavily on the paper, there was a slight lateral displacement; but this danger was reduced almost to *nil* by using at each corner two elastic bands at right angles, instead of only one, ensuring resistance to any rotatory jerk in either direction.

A little more practice in the manufacture of the glass pen enabled me to improve the delicacy and uniformity of the lines. The chief difficulty lay in breaking the capillary tube square to the axis. The tube delighted in oblique fracture, which gave an oblique pore when the edges were smoothed in the flame, and the oblique pore was apt to write unequally in different directions, often refusing to write at all on one side of the figure, when the pore was not facing its work. Only now and then was the first fracture fortunately square; generally I had to pick at it with the finger-nail to reduce its obliquity. Latterly, I tried to ensure success by coating the point with a thin layer of bees' wax, tracing a fine groove in the wax round the slender tube, and allowing a drop of solution of fluoric acid to adhere round the groove until the acid had eaten into the glass and made it ready to break at the ring of corrosion. Then the remainder of the wax was washed off with turpentine, and the point was ready for its "baptism of fire." In this way I succeeded well with one or two pens, but the process was rather troublesome. That "baptism of fire" was another dangerous crisis in the early life of the pen, for the risk was great that it might be exposed to the flame just a fraction of a second too long, sealing the liquid lips for ever. A good way of testing the size of the pore—it was much too small to be examined by the naked eye—was to blow through it and notice the size of the current of air disturbing the pale blue flame of the Bunsen's burner. Alternately dipping the point for the tenth of a second in the outskirts of the furnace, and quickly withdrawing it, and trying its calibre by the breath, it was seen that the air-current grew smaller and smaller after every dip in the flame, till I dared not dip again, and then I had recourse to a powerful pocket-lens to examine the size of the pore and the smoothness of its lip. The diameter of pore of the best pen I have succeeded in making is 1-500th of an inch.

I grew discontented with common black ink for my pendulum-curves; it was apt to coagulate and choke the pore, frequently requiring the solvent power of sulphuric acid to restore free passage. Besides, I wished to have several figures superposed on the same paper, yet so that each should remain distinct. So I procured a set of coloured inks at the stationer's, price 1*l.* per bottle, and with these I was able to give additional interest to the sheets that were rapidly accumulating from all these trials of new ink, new pens, and new pendulums. For I soon grew discontented also with my first pendulum; its tripod was not strong enough, and its cord-hinges were very weak, and were fast fraying under the strain of 50 lbs. of lead in habitual oscillation below, and I feared a snap and a crash. I kept it in my bedroom, and at midnight I heard it creak, and could not rest until I had insinuated a rush-bottomed chair between the legs of the tripod, immediately below the lead, to break the fall which I fully expected. However, nothing happened, and in the morning I changed the frayed string for a trustworthy cord, and slept securely next night. I also made a new tripod with the aid of three surveying-poles, and improved the attachment of the pen by making it slide in a hole bored in the end of the rod, with a lateral screw to fix it at any required height.

HUBERT AIRY

(To be continued.)

THE BRITISH ASSOCIATION MEETING AT EDINBURGH

EDINBURGH, Friday morning

THE work—and play—of the Edinburgh meeting of the British Association is now over; the visitors have all left, except such as have remained to do honour to the memory of the great Magician of the North; indeed, for the last two days the Southerners have divided their allegiance between the British Association and the Scott Centenary. Instead of Spontaneous Generation and the Germ Theory of Disease, the Solar Eclipse and the great Dredging Expedition, we have heard quite as much of Abbotsford and Dryburgh, Jock o' Hazeldean and the Laird of Dumbiedikes.

As announced in our letter of last week, the concluding meeting of the General Committee was held in the University on Wednesday at one o'clock, Sir William Thomson in the chair. Dr. Hirst read certain regulations which were proposed by the Committee on Recommendations to be adopted relative to the proceedings of the sections. They had reference to the organisation and constitution of the Sectional Committees, but were merely in regard to matters of detail. In an appended circular, authors of papers were reminded that, under an arrangement dating from 1871, the acceptance of memoirs, and the days on which they were to be read, were now as far as possible determined by organising committees for the several sections before the beginning of the meeting. It had therefore become necessary that an author should prepare an abstract of his memoir, of a length suitable for insertion in the published transactions of the Association, and that he should send it, together with the original memoir, to the general secretaries in London a certain time before the meeting. If it should be inconvenient to the author that his paper should be read on any particular day, he was requested to send information thereof to the secretaries in a separate note. These resolutions, after some discussion, were adopted. The next subject referred to the General Committee on Recommendations had reference to Dr. King's proposal that there should be a subsection of Anthropology. Before the consideration of that suggestion was concluded, another came from Section D of a more definite nature; and, on considering both propositions together, the Committee on Recommendations decided that they could not recommend the adoption of Dr. King's motion, but that they could strongly recommend the adoption of the other. They therefore recommended—"That in future the division of the Section of Biology into the three departments of Anatomy and Physiology, Anthropology, and Zoology and Botany should be recognised in the programme of the Association meetings; and that the president, two vice-presidents, and at least three secretaries shall be appointed; and that the vice-presidents and secretaries, who shall take charge of the organisation of the several departments, should be designated respectively before the publication of each programme." That would virtually amount to the direct recognition of the three departments of Section D. Logically, it would be impossible to take any of these departments from Biology to make a separate section of it; but they were recognised distinctly, and the gentlemen who would preside over these departments would be stated by name. The recommendation was agreed to.

The following recommendations were then read and unanimously adopted:—

"That the President and Council of the British Association be authorised to co-operate with the President and Council of the Royal Society, in whatever manner may seem to them to be best, for the promotion of the circumnavigation expedition specially fitted out for carrying the physical and biological Exploration of the Deep-sea into all the great oceanic centres.

"That the President and general officers, with power to

add to their number be requested to take such steps as may seem to them desirable in order to promote observations on the forthcoming Solar Eclipse.

"That the Council be requested to take into consideration the desirability of the publication of the periodic records of the advances made in the various branches of science represented by the British Association.

"That it is desirable that the British Association apply to the Treasury for funds to enable the Tidal Committee to continue their calculations; and that it is desirable that the British Association should urge upon the Government of India the importance for navigation and other practical purposes, and for science, of making accurate and continued observations on the tides at several points on the coast of India.

"That the Council of the Association be requested to take such steps as to them may seem most expedient in relation to the proposal of Dr. Buys Ballot to establish a telegraphic meteorological station at the Azores.

"That the Council be requested to take such steps as they deem wisest in order to promote the introduction of scientific instruction into the elementary schools throughout the kingdom; and, secondly, that the Council of the Association be requested to take such steps as may appear to them desirable with reference to the arrangement now in contemplation to establish leaving examinations, and to report to the Association on the present position of science teaching in the public and first grade schools."

Dr. Thomson read the report on the resolutions involving applications for grants of money, which were as follow:—

KEW OBSERVATORY.

The Council—Maintaining the establishment of Kew Observatory £300

MATHEMATICS AND PHYSICS.

Cayley, Professor—Mathematical Tables 50
Crossley, Mr.—Discussion of Observations of Lunar Objects 20
Tait, Prof.—Thermal Conductivity of Metals 25
Thomson, Prof. Sir W.—Tidal Observations 200
Brooke, Mr.—British Rainfall 100
Thomson, Prof. Sir W.—Underground Temperature 100
Glaisher, Mr.—Luminous Meteors 20
Huggins, Dr.—Tables of Inverse Wave Lengths 20

CHEMISTRY.

Williamson, Prof.—Reports of the Progress of Chemistry 100
Williamson, Prof.—Testing Siemens' new Pyrometer 30
Gladstone, Dr.—Chemical Constitution and Optical Properties of Essential Oils 40
Brown, Dr. Crum—Thermal Equivalent of the Oxides of Chlorine 15

GEOLOGY

Duncan, Dr.—Fossil Crustacea 25
Lyell, Sir C., Bart—Kent's Cavern Exploration 100
Harkness, Prof.—Investigation of Fossil Corals 25
Busk, Mr.—Fossil Elephants of Malta (renewed) 25
Harkness, Prof.—Collection of Fossils in the North-west of Scotland 10
Ramsay, Prof.—Mapping Positions of Erratic Blocks and Boulders 10

BIOLOGY

Stainton, Mr.—Record of the Progress of Zoology 100
Balfour, Prof.—Effect of the Denudation of Timber on the Rainfall in North Britain (renewed) 20
Sharpey, Dr.—Physiological Action of Organic Compounds 25
Foster, Prof. M.—Terato-Embryological Inquiries 20
Foster, Prof. M.—Heat Generated in the Arterialisation of the Blood (part renewed) 15
Christison, Prof.—Antagonism of Poisonous Substances 20

GEOGRAPHY

Murchison, Sir R.—Exploration of the Country of Moab 100

ECONOMIC SCIENCE AND STATISTICS

Bowring, Sir J.—Metric Committee 75

MECHANICS

Rankine, Prof.—Experiments on Fletcher's Rhysimeter 30

£1,620

The whole of the proposed grants of money were approved of, the wording of the last being modified as follows: "Experiments to measure the speed of ships and currents by means of the difference in heights of two columns of liquid."

Dr. Thomson read a number of recommendations adopted by the Committee on Recommendations not involving grants of money, which were also approved of.

At the concluding meeting of the Association, held in the Music Hall at half-past two o'clock, Sir William Thomson in the chair, Dr. Thomson read the recommendations for grants of money and also the recommendations not involving money grants, which had been adopted by the General Committee. Mr. Griffiths stated that the number of tickets issued for this meeting had been as follows: Old life members, 246; new life members, 28; old annual members, 311; new annual members, 127; associates, 976; ladies (transferable tickets), 754; foreign members, 21—total, 2,463. The money received for these tickets was 2,575*l*.

It will be seen that the recommendations were almost more important than in any previous year. The last in particular, relative to the introduction of scientific instruction into the elementary schools of the country, covers a wider ground than is often included in the action of the Association. Wisely carried out, this recommendation may be pregnant of the most important results in the future; and serves to show that at least our leading scientific men are alive to the need there is for a strenuous effort to place the education of the country on a level with the requirements of the times. The scheme to which we referred in our leader last week, relative to the extension and improvement of the present system of giving scientific lectures to the people, was warmly taken up, and a committee appointed to carry it out. The application to the Government asking for 2,000*l*. in aid of the observation of the Total Eclipse in December next was sent off the same day.

Among the more important papers read during the present week were two on Tuesday in Section A, which it was agreed should be taken together: *On Government Action on Scientific Questions*, by Col. A. Strange, F.R.S.; and *On Obstacles to Teaching Science in Schools*, by the Rev. W. Tuckwell. In both these papers, of which we shall give full reports, very important issues were raised. The discussion on them was a highly interesting one, and was led by Prof. Tait, who said there existed an absolute necessity for a State system of instruction in Science; and was carried on by the Rev. T. G. Bonney, Mr. G. J. Stoney, Mr. James M. Wilson of Rugby, Mr. Pengelly, Mr. Boyd Dawkins, and others. An entire unanimity was displayed as to the pressing importance of both the subjects introduced. On Wednesday, Section D was enlivened by another Spontaneous Generation controversy, introduced by Dr. H. C. Bastian, who was supported by Dr. Burdon Sanderson, to the extent that we have at present no evidence that fungus or other germs are contained in the air in a vital condition. In closing the discussion, the President of the Section said that the subject was still one which must be considered as undecided. The proposal to enter into the discussion of Mr. Crookes's "Psychic Force," and the whole phenomena of so-called "Spiritualism," was rejected for want of time.

The excursions, which were arranged for yesterday, were uniformly well carried out and successful. About eighty ladies and gentlemen paid a visit to Hopetoun House and Dalmeny Castle. Forty ladies and gentlemen availed themselves of the trip to Rosslyn and Penicuik, and over 300 visited Melrose, Dryburgh, and Abbotsford.

The excursion of the Geologists was to Siccar Point and Fast Castle, under the leadership of Prof. Geikie. The object of the excursion was to visit the coast-line of Berwickshire, and examine the natural sections there, which have become classic in geology through the writings of

Hutton, Playfair, and Hall. The chief features of geological interest examined were:—First, the manner in which, at Siccar Point, the vertical and highly-inclined Lower Silurian strata are covered unconformably by the gently-inclined Upper Old Red sandstone. It was this section which furnished Hutton with one of the most telling arguments for his "Theory of the Earth," and his search and discovery of which have been so graphically described by Playfair. The sections presented indeed a magnificent example of unconformable stratification; the Old Red strata lying almost horizontally on the vertical Silurians, a phenomenon expressed by the local papers by the phrase, not devoid of a certain dry humour, that "the Old Red rested uncomfortably on the Silurian!" We are bound however to state that on the whole the Edinburgh press was well up to the occasion; the Reports of the Addresses, Lectures, and Sectional Proceedings were good and full, and no pains were spared to make them really first-rate. The reports in the *Scotsman* should be mentioned in particular as unusually excellent.

The second point examined was the plication of the Lower Silurian rocks. Along this wild coast-line the greywacke and shale are thrown into many anticlinal and synclinal curves, extending from top to bottom of the cliffs, which are here in some places more than 500 feet high. Along the part of the coast to be examined by the excursionists the best folds occur at Fast Castle. It was the curving of these rocks which attracted the attention of Sir James Hall, and led him to investigate the subject in his well-known paper on "The Vertical Position and Convolutions of certain Strata," some of the illustrations from which may now be found copied into almost every text-book of geology.

A party of naturalists, numbering about sixty, joined in the Dredging Expedition off the Bass Rock. Amongst the gentlemen present were:—Prof. Wyville Thomson, Admiral Sir Edward Belcher, Sir Walter Elliott, Prof. Crum Brown, Prof. Margo, of Pesth; Prof. Purser, of Belfast; Dr. Colding, of Copenhagen; Dr. Lütken; Dr. Copeland, of Parsonstown, Ireland; Dr. Lindeman, of Bremen; Mr. Shapter, Mr. G. Barclay, Mr. Ray Lankester, Mr. Shepherd, and Mr. Davis. There were also a number of ladies in the party.

About a hundred members and associates of the Association took part in a botanical excursion to the top of Ben Ledi, under the leadership of the veteran Prof. Balfour.

The Conversazione held on Tuesday evening was a very good one; over 1,400 ladies and gentlemen attended. In addition to the varied contents of the Museum of Science and Art where the Conversazione was held, and which are themselves of no ordinary interest, the following were the most interesting objects exhibited:—Mr. Fowler's flint implements of the drift, Spencer's local heliostat, Dr. Gladstone's experiments in the crystallisation of metals by electricity under the microscope; flint implements from Palestine.

It only remains to be added, that, thanks to the admirable arrangements of the energetic local secretaries, Dr. Crum Brown and Mr. Rollo, everything went off well during the meeting; and the third Edinburgh meeting of the British Association will be looked back upon as one of the most enjoyable of a long series, as it certainly has been the most important for many years.

SECTION A.

THE greater part of the first day's session in this Section was occupied by a paper *On the Thermodynamics of the General Oceanic Circulation*, by Dr. W. B. Carpenter, and the interesting discussion which followed.

The inquiries in which the author, with his colleague, Prof. Wyville Thomson, has recently been engaged, into the physical condition of the deep sea, have furnished a new set of facts in

regard to its thermal condition, which seem to point to conclusions very different from the doctrines usually received in regard to the movements of oceanic waters and their influence on climate. It may now be asserted as probable that the temperature of the bed of the ocean below 2,000 fathoms is everywhere, even under the equator, but little above 32° F., while it may be as low as 29°·5° F. in particular channels of less depth, such as that which lies between the Shetland and the Faroe Islands. That this depression of temperature has no dependence on depth *per se*, appears to be conclusively proved by the fact that it does not show itself in the Mediterranean, for though depths of 1,600 fathoms have been sounded in its western basin, and 2,000 in its eastern basin, the temperature below the surface stratum of about fifty fathoms, heated by direct solar radiation, remains at a uniform level of about 54° to the very bottom, being in fact the average winter temperature of this vast mass of water, which may be regarded, as to all but its surface, in the light of an inland lake.

Now, if the condition of the Mediterranean be compared with that of the eastern border of the Atlantic under the same parallels, we find a most striking contrast in their thermal conditions. The superheating of the surface-stratum by direct solar radiation shows itself in the latter as in the former; below the surface-stratum there is a very gradual descent of the thermometer from about 53° to 49°, which last is the temperature at 800 fathoms; in the 200 fathoms below this there is a rapid loss of 9°, bringing the thermometer down to 40° at 1,000 fathoms; whilst beneath that line there is a further gradual descent with increase of depth, 36°·5 being the lowest temperature yet observed in this region. The author regarded this anomaly as due to the fact that the former was virtually cut off from the great oceanic circulation that diffuses over the latter the waters that have been chilled in the polar seas. The author found that the *primum mobile* of this circulation was not in equatorial heat (which being applied to the surface could exert no motor force beneath the thin stratum which it directly affects), but in polar cold, which by its action on the surface-water would produce the same kind of movement from above downwards, as heat applied at the bottom does from below upwards.

Supposing the whole surface of a limited basin of sea-water to be exposed to intense cold, the surface film, when rendered heavier by reduction of temperature, will sink, to be replaced from the warmer stratum beneath. The new surface-stratum will then be cooled; and the same process would be repeated until the temperature of the whole basin comes to be reduced as low as the cooling action will carry it—it may be down to 27° or even 25°. But suppose that only a portion of the surface area of the basin be exposed to cold, the phenomena would be different. (1) As each surface-film cools and sinks, its place will be supplied, not from below, but by a surface influx of the water around; and (2) the bottom stratum will flow away over the deepest parts of the basin, while, since the total heat of the liquid is kept up, there will be an upper stratum which will be drawn towards the cold area, to be precipitated to the bottom and repeat the action. Applying this principle to the great oceanic area that stretches between the Equator and the Poles, we should expect to find the upper stratum moving from the Equator towards the Poles, and its lower stratum from the Poles towards the Equator. That such a movement really takes place is indicated, as it seems to me, by various facts.

(1.) The general prevalence of a temperature not far above 32° over the deepest parts of the great ocean basin, which could scarcely be maintained if there were not a continual flow of cold water from the polar area.

(2.) The distinction between the upper and lower strata of Atlantic waters is shown by the change of temperature between 800 and 1000 fathoms.

(3.) The existence of a movement of warm surface-water towards both polar areas. From a consideration of these facts in detail, the author was led to the hypothesis of a north-easterly movement of a vast stratum of oceanic water, having a depth of at least 600 fathoms. In the remaining portion of his paper Dr. Carpenter discussed the different causes of horizontal and vertical currents. He was inclined to believe that the propulsive force of the trade winds produced only a horizontal motion.

Sir W. Thomson said that Dr. Carpenter's explanation had been so lucid and demonstrative that he thought little remained to be said. It seemed to him that Dr. Carpenter thoroughly established his case. The distinction drawn by him between horizontal and vertical circulation was important. When the path of least resistance was in a wide circuit along the surface, then the chief return would be along the surface. In an

open ocean where there was a prevalence of winds in a certain direction over one part of it, it seemed necessary that the currents produced by that wind should be as Dr. Carpenter had maintained. The only case in which he could conceive of a return along the bottom produced by wind was one of great interest, but in which the circumstances were precisely opposite to those of an open oceanic circulation, viz. in the case of a frith or fiord. The elevations of 6, 8, or 10 feet, which we know result from high wind, must be thus explained; the return circulation cannot but be along the bottom. In the case of a frith, if the whole surface is carried up in a current, the water must get away somewhere. If there were a strong breeze in narrow waters when the whole surface was broken up, there would be a great deal of surface drift; but even without breaking up a surface there was a current necessarily accompanying waves at sea when the height of the wave was not infinitesimal, *i.e.*, when it was not very small in comparison with the length; sometimes there was a great surface current amounting to three or four knots in these circumstances, and there must be an equal outflow at the bottom. Dr. Carpenter's explanation of the vertical circulation seemed to make the whole thing perfectly clear. Ocean currents were altogether unknown, with the exception of a few isolated cases, and even regarding these the knowledge was not nearly practical enough for the ordinary purposes of navigation. In the operations of 1866 to recover the cable of 1865, it was discovered that the success or non-success altogether depended on the management of the ocean current. Captain Moriarty, who was chiefly concerned in finding the ship's place, came to the conclusion that the whole subject of ocean currents ought to be made a matter of hydrography, and certainly it was an object of all others appropriate to a nautical country. The question of temperature was also of great practical importance, as the temperature of the sea bottom along which the cable was to be laid was of enormous importance to the enterprise. If a cable showed certain signs at 40° F. it was good, if it showed the same signs at 40° F. it was bad. Another most serious practical want was to know precisely the temperature of the cable when laid, in order that if there was a fault its temperature might be accurately determined.

Prof. Stokes said that if he had risen first, he would have pointed out what had been so well stated by Sir W. Thomson, that the only case in which a vertical circulation could be produced in the horizontal blow forward by wind, was in the case of a narrow channel. If a portion of a widely-extended ocean were blown on by the wind, the water would be propelled forward, but the tendency would be to take it in from all directions, not merely from one, so that the inflow would be lost in minuteness. That a surface-current is a necessary accompaniment of waves, seemed pretty obvious. If waves are already in existence on the surface of water, it is evident that their backs must be more strongly acted on than their fronts by the wind; there must be a horizontal resultant forward which must push on the water somehow or other; the fact of the existence of these waves implied that there was already a surface current of a certain amount.

Mr. Robert Russell said he could only go a certain distance with Dr. Carpenter; he considered the effect of polar cold and equatorial heat to be comparatively small compared with the wind. The Atlantic itself narrows so much towards the North Pole, that its vast surface is forced by the south-west wind to the northern ocean, and is forced into it in spite of polar cold.

Prof. G. C. Foster said that a possible cause of the formation of currents was the coexistence of different specific gravities in neighbouring quantities of water.

Dr. Carpenter said it gave him great satisfaction to hear the general agreement of Sir W. Thomson with the views that he had advanced; he had expressly spoken of the open ocean, and mentioned as excepted cases as the Gibraltar current. With regard to cables, Capt. Sherard Osborne had mentioned to him that the cable recently laid down in the Eastern seas towards China was generally in shallow water and therefore warm, so as to diminish the conducting power of the wire, but at one point it dipped down into a hole, and there the temperature having fallen the conducting power was greatly improved. Everyone knew that when the cable was cut and buoyed in 1865, there was a long wire rope with a buoy attached to it. It got adrift, and was seen by an Atlantic mail steamer 10° to the southward. One would have expected it to the North-East, through the influence of the Gulf Stream. It was suggested that the long rope had broken away at the bottom; that its long tail was hanging in the sea, and the action of the great lower movement to the

south might have been stronger on the tail than the action of the surface water on the upper portion of the rope.

Mr. Buchan said that the Scottish Meteorological Society were conducting investigations which would settle what were the winds and currents over each degree of a portion of the Atlantic.

Mr. Scott said he hoped to give Mr. Buchan charts of the currents over the area such as were never before possessed. They were derived from all available sources of information.

Sir W. Thomson said it seemed demonstrable that in all water above five or ten fathoms deep, the current under return due to surface drift was insensibly small, and he thought that this demonstrated Dr. Carpenter's statement, that the main current could not be produced by wind, though the wind might produce very considerable surface currents.

Prof. Colding, who stated he had been working at the same subject for many years since, made some remarks on the effect of the earth's rotation on the currents, and

Prof. Tait remarked that the discussion well illustrated the use of the British Association.

Observations Physiques en Ballon, by M. Janssen.

SECTION B.

THIS section did not sit on Saturday, and on Monday the proceedings commenced with two short papers by the President, Dr. Andrews, *On the Dichroism of the Vapour of Iodine and on the Action of Heat on Bromine*. The fine purple colour of the vapour of iodine arises from its transmitting freely the red and blue rays of the spectrum, while it absorbs nearly the whole of the green rays. The transmitted light passes freely through a red copper or a blue cobalt glass. But if the iodine vapour be sufficiently dense, the whole of the red rays are absorbed, and the transmitted rays are of a pure blue colour. They are now freely transmitted as before by the cobalt glass, but will not pass through the red glass. The solution of iodine in bisulphide of carbon exhibits a similar dichroism, and according to its density appears either purple or blue when white light is transmitted through it. The alcoholic solution, on the contrary, is of a red colour, and does not exhibit any dichroism. If a fine tube be filled one half with liquid bromine and one half with vapour of bromine, and after being hermetically sealed, is gradually heated until the temperature is above the critical point, the whole of the bromine becomes quite opaque, and the tube has the aspect of being filled with a dark red and opaque resin. A measure of the change of power of transmitting light in this case may be obtained by varying the proportion of liquid and vapour in the tube. Even liquid bromine transmits much less light when heated strongly in a hermetically sealed tube than in its ordinary state. In connection with this subject, Mr. Dewar exhibited an experiment illustrating the action of light upon peroxide of chlorine.

The report on the Utilisation of Sewage was presented by Mr. Grantham. It was divided under the following heads:—(1) Experiments on Britton's Farm, Mr. Hope. (2) Comparison of results during winter of Croydon, Norwood, and Britton's Farm experiments, Dr. Corfield. (3) Report on Analysis in connection with above, Dr. Corfield. (4) Upward Filtration of Sewage at Ely, Dr. Corfield. (5) Phosphate Process, Dr. Corfield. (6) Dry-Earth System at Lancaster, Drs. Corfield and Gilbert. Dr. Bischof read a paper *On the Examination of Water for Sanitary Purposes*, in which he sought to show that the appearance of the residue obtained by evaporation when seen under the microscope afforded a ready method of detecting sewage contamination.

Dr. Otto Richter contributed a paper *On the Chemical Constitution of Glycollic Alcohol and its Heterologues as viewed in the light of the Typo-nucleus Theory*. The Abbé Moigno gave an account of the history and working of the photographic post, and exhibited a number of collodion films containing microscopic photographs of letters and despatches. Every film reproduced twelve or sixteen folio pages of printing, and contained on an average 3,000 despatches. The whole of the official and private despatches came by pigeons during the investment of Paris, numbered about 115,000, weighing in all about two grammes.

Dr. Wright gave an account of some experiments *On the Essential Oil of Orange Peel*. It has been shown that this oil consists principally of a hydrocarbon, hesperidene, $C_{10}H_{16}$, and an amorphous resin of the formula $C_{20}H_{30}O_3$. When hesperidene is boiled "per ascensum" with sulphuric acid and potassium bichromate, carbon dioxide is slowly evolved, and acetic acid produced, whence it is inferred that the structure of the hydrocarbon is CH_3

$CH(C_8H_{12})$.

SECTION C.

AFTER the reading of Prof. Geikie's Report on the Progress of the Geological Survey, Mr. James Thomson, F.G.S., read a paper *On the Age of the Stratified Rocks of Isla*. He gave an account of the general character and relations of the beds, which are much affected by intrusive igneous rocks, and illustrated the subject by two sections—one of the east coast of Isla and a transverse section of the same. His paper contained much detail, which was hardly of sufficient interest to a general audience, but it clearly showed an amount of careful investigation that will prove of great value to geologists.

In the discussion which followed, Mr. Geikie differed from the author in his identification of the Fundamental Gneiss, and he thought sufficient evidence of its presence had not been brought forward. Professor Harkness regarded the Gneiss as corresponding with the newer gneiss of the Highlands. Mr. Thomson, in reference to some remarks upon *Eozoon*, stated that having sent to Dr. Carpenter some specimens of the rock, he reported that *Eozoon* structure was not sufficiently distinct to warrant him in calling it *Eozoon*.

The *Third Report of the Committee on Earthquakes in Scotland* was communicated by Dr. Bryce, F.R.G.S., F.G.S. There was nothing, however, of importance to make known, but a few slight earthquakes having been felt—one at Lochaber and another in the upper part of the Firth of Clyde. In regard to the latter, very little information that could be depended upon had been obtained, but there was less doubt respecting the other. It occurred in a district in which some of our most severe earthquakes have taken place. However, in the absence of any recording instruments, it has been impossible to state with certainty the intensity of the shocks. The Committee recommend the adoption of a much simpler form of Seismometer than that at Comrie belonging to the Association; they also proposed placing such an instrument at a number of the meteorological stations which are within the area liable to disturbance.

Mr. Henry Woodward, F.G.S., read his *Report on the Structure and Classification of the Fossil Crustacea*, first noticing the new forms discovered and described during the past year, which amounted in all to 21 species, including 6 Decapods, 1 Amphipod, 2 Isopods, 1 Eurypterid, and 13 Phyllopods. He referred to the wide distribution of a new Cretaceous Isopod (*Palæga Carteri*) which had been found in Upper Silesia, at Turin, and in three localities in England, and pointed out that if the conclusions arrived at by Mr. Billings and himself as to the Trilobites possessing legs be established by further research, then that group would carry the Isopodous class back in time to our earliest Palæozoic rocks.

The structure of *Dictyoxylon* (*D. Grievii*), a new species of which had been discovered by Mr. G. J. Grieve, near Burntisland, formed the subject of some remarks by Prof. W. C. Williamson. He regarded the form as of a type belonging to the Coal Measures.

SECTION D.

SUB-SECTION.—ZOOLOGY AND BOTANY

THE Committee for the Foundation of Zoological Sections in Different Parts of the Globe, reported that since the last meeting at Liverpool steps were taken by Dr. Dohrn to secure the moral assistance of some other scientific bodies, that the Academy of Belgium had passed a vote acknowledging the great value of the proposed Observatories. Besides, the Government at Berlin had given instruction to the German Embassy at Florence and to the General Consul at Naples for Germany to do everything to secure success to Dr. Dohrn's enterprise. Next October the building at Naples will commence, under Dr. Dohrn's personal superintendence, who will be accompanied by the assistant architect of the Berlin Aquarium. The contractor is to finish the building in one year, so that in January 1873 the Aquarium in Naples may be hoped to be in working order.

The Naples Observatory being thus arranged for, the Committee urged the importance of establishing a Zoological Station in the British Islands, and to the opportunity, which is now offered for such a proposition in consequence of the cessation of the grant to the Kew Observatory. In the same way as the Association took the initiative in the foundation of Meteorological Observatories, so may they legitimately, and with every prospect of success, take in hand the foundation of Zoological Observatories. Until a recent date the Association has given considerable sums of money to dredging explorations; but in consequence of the advance in Zoological Science the problems are so much

changed, and their nature is of such a character as to demand the assistance of the Association in other directions. The careful study of the development and the habits of marine animals can only be carried on by aid of larger Aquariums and cumbersome apparatus, which an individual could hardly provide for himself. This and the copious supply of animals for observation can be provided by such a co-operative institution. There can be little doubt of the convenience to Naturalists and the benefit to science which would be brought about by the foundation of a Zoological Station in the British Isles.

The Committee recommends that a Committee of the Association be formed for the purpose of erecting a Zoological Station at a convenient place on the South Coast of England, say Torquay, and that a sufficient sum of money be placed at their disposal either by a single or a series of annual grants.

Prof. E. Perceval Wright suggested that Bantry Bay would be a good place for establishing such a station. Here scientific research could be carried on at a very trifling expense, and although no return would be obtained from visitors to the Aquarium, yet from this station other Aquaria might be supplied at a remunerative rate. Prof. Lawson remarked that such a station might be turned to good account for the investigation of the marine Flora as well as Fauna. Prof. Dunns trusted the Department would make a very hearty recommendation to the Council of the Association on this subject, in which Prof. Wyville Thomson concurred; and Dr. Sclater, who had read the Report, promised that the matter should be laid before the full Committee of the Section.

The Report was signed by Dr. A. Dohrn, Prof. Rolleston, and Dr. Sclater.

SUB-SECTION.—ANTHROPOLOGY

PROF. W. TURNER opened the Section with an address from the chair, in which he traced the rise and growth of the science of Anthropology, and the vicissitudes in the fortunes of the sub-section over which he presided. Anthropology was first allowed place in the proceedings of the British Association under the head of Zoology and Botany; then it was assigned to the department of Geography, and at last, in 1865, resumed again its old place under the newly named department of Biology, which embraced not merely Zoology and Botany, but the whole science of organisation. The science of man obviously has an organic connection with Biology, and ranges itself naturally under that master science. Within its scope falls everything which has a direct bearing on man, and as nearly every branch of human knowledge has a relation, more or less, to man, questions may occasionally arise whether papers brought before the sub-section come within its province or more naturally belong to the other sections. The most satisfactory way of solving this difficulty would be for the different sections concerned to come to a common understanding, that all papers, which treat of the origin and progress of mankind, should be forwarded to the Department of Anthropology. The term Anthropologists—*ἀνθρωπολόγοι*—was first used by Aristotle, as to denote "gossips," or talkers about men rather than facts. And if we lay claim to the title, let it not be in this sense, but in the nobler and wider sense of humble and patient students of the great science of human nature.

Dr. Beddoe then read a paper *On the Degeneration of Races in Britain*, in which he urged the necessity of systematic inquiry into the physical changes which are now taking place in our population. Of the four countries—England, Wales, Scotland, and Ireland—the first, which is the richest, and considered to be the most advanced in material civilisation, and whose habits and modes of life are more and more imitated by the others, is, according to Edward Smith's reports on the subject, the one in which the people are most scantily and ill-nourished. The scarcity of milk especially, as to its supply to children in towns and in dairy districts, is a growing evil, and one of national importance. Here may be mentioned, as having probably a relation to the quality of the food, and possibly to this very defect of milk, the apparently growing evil of unsound teeth, which, again, seems to advance *pari passu* with the advance of material civilisation, and is worst among the English and the townsmen of the United States, not so conspicuous among the Scotch, and decidedly at the minimum among the Irish. Certain changes in the process of natural selection, as it operates on our people, seem to be on the whole detrimental to the standard of physical type. Emigration drains away large numbers of the stronger and more energetic young men from the best of our districts; so do the military and civil service in India; and their voids are supplied to a less extent than they used to be from the

rural population, wherein the rates of marriage and of birth are much less than in that of the towns. The classes that yield the largest number of births are, beginning with the least important—(1), fishermen; (2), miners, especially coal-miners, and the like; (3), the proletariat of large towns. Whatever may be said of the two former, this last and most important is, physically, about the worst developed in the kingdom. Formerly it did not tend to increase in numbers, relatively, to other classes, because the death-rate in the worst quarters of towns was so high as to balance or overbalance the birth-rate—such was the case not long ago in Liverpool, for example. But the effect of sanitary improvements has been so considerable, that the rates of sickness and death in these quarters are being decidedly ameliorated; and this improvement, regarded dispassionately, is no more an un-mixed good than are good things in general; for the increase in the number of survivors brings about a disproportionate augmentation in the numbers of the class in question, and thus lowers the average standard of physical development.

SECTION G.

MECHANICAL SCIENCE

OPENING ADDRESS BY THE PRESIDENT, PROF. FLEEMING JENKIN

In addressing you on the subject of Mechanical Science in our ancient university, I propose to speak on the somewhat threadbare topic of technical instruction. The panic with which some persons regarded the rapid improvement made abroad in manufactures has subsided, but I hope that you will be all the more ready on that account to listen to a few suggestions as to steps which may be immediately taken to improve the education of those who apply science to practical ends. The subject does not owe its prominence to any events of to-day or of yesterday; it has long been, and will long be, of paramount importance to this country that the education of the producers of wealth should be such as will enable them, not merely to compete on advantageous terms with foreigners, but rather to master the great forces of nature by which we work. That we have gained some triumphs can be no reason for relaxing our efforts. With each advance further advance becomes more difficult, and requires more knowledge. The first rude implements and processes employed by man certainly required for their explanation or acquirement no book-learning; but as processes become complex, and implements develop into machines, as the occupations of men differ more and more, practice alone is found insufficient to give skill, and study becomes the necessary preparation for all successful work. Our first engineers were not learned men; strong good sense and long practice enabled them to overcome the comparatively simple questions with which they dealt. All honour to those great men; but we who have to deal with more complex, if not with vaster problems, cannot trust to good sense alone, even if we possess it, but must arm ourselves by the study of science and its application to the arts. This being granted, how shall it be done? I need not trouble you by refuting the absurdities of a few men, who would have those things taught at schools which have hitherto been taught by practice. What has been taught by practice must still be taught by practice. The business of the school is to teach those things which practice in an art will not teach a man. Let us apply this principle to engineering—the most scientific of all professions. It will be most useless to lecture on filing and chipping; it will be useless to describe the mere forms and arrangements of vast multitudes of machines; one kind of knowledge of the properties of materials can only be acquired, as it always has been acquired, by actually handling them; and the knowledge of the arrangement of a machine is far better learnt by mere inspection than from fifty lectures; moreover, it can be acquired by an intelligent man, even if he be wholly unlettered. Book learning about estimates, the value of goods, methods of superintending work, and dealing with men, is foolishness. Written descriptions of puddling a clay embankment, excavating, and such operations, give no knowledge; and yet a vast mass of such knowledge must, at some time of his life, be acquired by the engineer, and the student cannot be employed as an engineer until he has laid up a store of such knowledge. Colleges cannot give him this; he must serve an apprenticeship in fact if not in form; young foreigners taught in colleges serve their apprenticeship, at the cost of their employers, during the first few years of their professional life. We call the tyro an apprentice or pupil, and he pays his master instead of being paid by him. I have the strongest feeling against any attempt to substitute collegiate teaching for practical apprenticeship; so far

as colleges attempt to teach practice, they are and will be a sham in this country and in all others. The work of a college is to teach those sciences which are applied in the arts; but it can go a little further, and indicate to its students how the application is made in at least a few selected instances. Applying this dictum to the education of an engineer, his college can teach him mathematics, natural philosophy, chemistry, and geology. No one can doubt that a youth well trained in these branches of knowledge will, even with no further teaching, learn more during his apprenticeship, and during his whole professional life will take a higher standing, than the man of equal intelligence untrained in science. College can, however, do more than this; it is found that a lad will go through a considerable number of books of Euclid, and yet see so dimly how his knowledge is to be connected with practice that he may be unable even to compute the area of a field the dimensions of which are well known to him; and far more is it seen that a man may be fairly grounded in mathematics, and yet have very little idea how to apply his knowledge to mechanical problems. It is the business of those who hold such chairs as mine to point out the connection between pure science and practice; to show how mathematics are employed in mensuration and in mechanical calculations; to show how the truths of physics are made use of in designing economical machinery, as when we teach the connection between the laws of heat and the steam engine. The student who has once grasped the fact that there is a real connection between practice and theory will seldom be at a loss how to find or search for that connection in after life. The student thus prepared knows what he has to learn from practice, and need not lose precious time in blundering over the numberless scientific problems which practice is sure to suggest but can never solve. The education of the architect, the practical chemist, the manufacturer, and the merchant, must be similar, *mutatis mutandis*, with that of the engineer. Assuming, then, that the education of those who are to follow more or less scientific pursuits must consist in acquiring, first, that theoretical knowledge which practice cannot give, and, secondly, the practical knowledge which schools should not attempt to give, there remains the question whether the theoretical preparation should be given in special colleges, or universities such as our own. I have no hesitation in preferring the university. Mathematics, physics, chemistry, geology, botany, languages, all form elements required in various combinations in the education of all students. There is but one kind of mathematics, one kind of pure physics, and so forth. Surely it is better that we should teach the men belonging to different professions side by side, so long as the matter taught is to be the same. There are many dangers in an opposite course. There are not a sufficient number of competent teachers to allow of much differentiation. Segregation at an early age is not apt to foster professional peculiarities and narrow-mindedness. There is great danger, if physics are to be taught specially to engineers, that a special kind of physics, erroneously supposed to be specially useful to them, will be invented. Lastly, the contact of students and professors of one faculty with the students and professors of other faculties is very beneficial to all. Do not, therefore, cripple old universities by withdrawing from them a portion of their students and their professors, to set up special, professional, or technical colleges of a novel kind, but rather add by degrees to the power and usefulness of old institutions, and found new colleges and universities after the model of those which are found to have done good work. As an example of what may be safely done, I consider that in Edinburgh we require a chair of architecture, and lectureships on navigation and on telegraphy. There is, further, much want of a teacher of mechanical drawing. The professors of physics and chemistry require additional accommodation for practical laboratories, and additional assistance. If these additions were made, our college would, in my opinion, meet all the requirements for superior technical education in this part of Scotland. For 2,000*l.* per annum all these additions might be made. Notwithstanding the acknowledged importance of education establishments for giving the higher kinds of instruction are never self-supporting, and students must everywhere be bribed to come and learn. Immediate prizes, in the form of bursaries, scholarships, and fellowships, are required to induce men to cultivate the older fields of learning, and similar bribes are needed to promote the tillage of the more recently colonised domains of applied science. The Whitworth scholarships are a noble example of munificence thus directed, although, in my opinion, the examination requires considerable reform. I hope that further benefits of this kind will be conferred on those colleges which give efficient teaching. Local ambition is

most effectually stirred by local prizes, and I regret to find a certain apathy among students here with respect to the Whitworth competition. This appears to arise partly from dissatisfaction with the mode of examination, and partly from the fact that the examiners are men not well known in Scotland. Leaving the question of technical training for the upper classes, and the still larger question of scientific teaching in second grade schools, the consideration of which would lead us too far a-field, I purpose to say a few words on the technical education of the skilled artisan. This we must treat on the same principles as have been applied to professional teaching. We must endeavour to prepare the lad in school, by teaching him those things which he cannot learn in work-hops, but which will enable him to work with greater intelligence while acquiring and applying his practical knowledge. I shall not now speak of the general education which should make him a good man, and which should open to him those great sources of rational enjoyment arising from culture; I will restrict myself entirely to his preparation for becoming an efficient workman. I have in many places said, and I cannot say too often, that the great want of the workman is a knowledge of mechanical drawing. Unfortunately, I can obtain little attention from the general public to this demand for the workman. Very few persons not being engineers know at all what mechanical drawing is. I am sorry to say that some examiners in high places, who direct the education of the country, know very little more than the general public, and teachers who should give bread give chaff. I have lived much abroad, and come into close contact both with English and foreign workmen, and I unhesitatingly say that the chief, if not the only, inferiority of Englishmen has been in this one branch of knowledge. I must explain to some of my hearers what mechanical drawing is. It is the art of representing any object so accurately that a skilled workman, upon inspecting the drawing, shall be able to make the object of exactly the materials and dimensions shown, without any further verbal or written instructions from the designer. The objects represented may be machines, implements, buildings, utensils, or ornaments. They may be constructed of every material. The drawings may be linear, shaded and coloured, or plain. They must necessarily be drawn to scale, but various geometrical methods may be employed. The name of mechanical drawing is given to one and all those representations the object of which is to enable the thing drawn to be made by a workman. Artistic drawing aims at representing agreeably something already in existence, or which might exist, and for the sake of the representation; mechanical drawing aims at representing the object, not for the sake of the representation, but in order to facilitate the production of the thing represented. Now, I say that it is this latter kind of drawing which is so vastly important to our artisans, and hence to our whole wealth-producing population. Very few workmen, or men of any class, can hope to acquire such excellence in artistic drawing that their productions will give pleasure to themselves and others; but a great number of workmen must acquire some knowledge of the drawings of those things which they produce, and there is not one skilled workman or woman who would not be better qualified by a knowledge of mechanical drawing to do his work with ease to himself and benefit to the public. Mechanical drawing is a rudimentary acquirement, of the nature of reading, writing, and arithmetic. In order that a man may understand the illustrated description of a machine, he must understand this kind of drawing. To the general public an engineering drawing is as unintelligible as a printed book is to a man who cannot read. The general public can no more put their ideas into such a shape that workmen can carry them out, than a person ignorant of writing can convey their meaning on paper. Reading and writing on mechanical or industrial subjects is impossible without some knowledge of the art I am pressing on your attention. This art is taught abroad in every industrial school; a great part of the school-time is given up to it. In a Prussian industrial school one-third of the whole time is given to it. A French commission on technical education reported that drawing, with all its applications to the different industrial arts, should be considered as the principal means to be employed in technical education. Now, I deliberately state that this subject is not taught at all in England, and that the ignorance of it is so great that I can obtain no attention to my complaints. A hundred times more money is spent by Government to encourage artistic drawing than is given to encourage mechanical drawing, and I say that mechanical drawing is a hundred times more important to us as a nation. Moreover, the little *quasi*-mechanical drawing which is taught is mostly mere geometrical projection, a subject

of which real draughtsmen very frequently, and with little loss to themselves, are profoundly ignorant. Descriptive geometry and geometrical projection are nearly useless branches of the art, and the little encouragement which is given is almost monopolised by these. Mechanical drawing proper is confined to those who pick it up by practice in engineering offices. These draughtsmen are often excellent, and on their behalf I claim no other teaching. I speak for the artisan who makes and for him who uses machinery. There are two ways in which our shortcomings may be remedied. First, the schools of art now established in this country should be enlarged so as to teach real mechanical drawing, and the examinations conducted by the Science and Art Department should be greatly modified; secondly, the drawing which is to be taught in the schools under the superintendence of the new school boards may be and ought to be mechanical drawing. Freehand drawing, as a branch of primary education, will, I fear, be a useless pastime; but whether that be so or not, I am certain that the accurate and neat representation of the elementary part of machinery and buildings would be popular with the pupils, and could be effectively taught. This kind of drawing educates hand and mind in accuracy, it teaches the students the elements of mensuration and geometry, and it affords considerable scope for taste where taste exists. The chief difficulty will be to obtain competent teachers. I should occupy you too long were I to attempt to show how these must themselves be trained. My chief aim to-day has been to claim attention for a most important and wholly neglected branch of education. I shall probably be expected to urge the teaching of other natural sciences in our primary schools; nothing, indeed, would give me greater pleasure than to think this could be done. I confess I doubt it, and while our second grade schools are what they are in this respect, and while the Cambridge examination for a degree in applied science is what it is, I dare not think of natural science classes in our primary schools. I shall be delighted if I am mistaken, but I am certain that mechanical drawing deserves our first attention, as most immediately useful to the artisan, and most easily taught. The very books on natural science which are published in England cannot be properly illustrated for want of competent draughtsmen, and children would be unable to follow the illustrations and diagrams, if ignorant of the principles on which they are constructed. I look rather to good reading books, explained by intelligent masters, as the best manner of teaching the elementary and all-important truths of natural science. No man could do better service than in compiling such reading-books, and there are few wants more urgent than that of masters competent to enlarge upon texts which would thus be put into their hands. The education of our workmen is far more incomplete than that of our professional men. Small additions to existing institutions will meet the want of the latter; but for the former the institutions have to be erected almost from the foundation.

SCIENTIFIC SERIALS

In the *Scottish Naturalist* for July, Dr. Lauder Lindsay finishes his article on Natural Science Chairs in our Universities, and concludes by pointing out that in this country the most eminent of our naturalists, Darwin, Owen, Huxley, Hooker, Bentham, Berkeley, Murchison, Lyell, Lubbock, Sclater, Wallace, Gwyn Jeffreys, are not, and never were, University professors, while many of the occupiers of natural history chairs have never properly discharged the duty of professors, and their opinions carry no authority in scientific matters. The remainder of the number is occupied by short articles and notes on various points of Scottish natural history.

THE greater part of the *American Naturalist* for July is occupied by two long articles, entitled, "The Ancient Indian Pottery of Marajó, Brazil," by Prof. C. F. Hartt, and "Application of the Darwinian Theory to Flowers and the Insects which visit them," both illustrated with cuts. The latter is a re-translation of Prof. Delpino's annotated translation into Italian of Dr. Müller's address at Lippstadt in 1869. The former is a very interesting account of the pottery exhumed from the Indian burial places at various localities in the Valley of the Amazonas. These vases were used for the reception of the remains of the dead, and are found associated with rude idols. We have no historical record of the tribe that built the Marajó mounds, and no record of the existence of any tribe in the Lower Amazonas within historic times that buried its dead in jars. Prof. Hartt does not agree with von Martius in supposing these